

13th August 1976

Sir Karl Popper FRS
Fallowfield
Manor Road
Penn
Buckinghamshire

Dear Karl

We are going to the Salk for 8 to 9 months, starting in September, and I have to go to Greece for two weeks before that, so let me be brief.

When one discusses whether chemistry can be reduced to physics it is implied that one knows what parts of science lie in chemistry and what in physics. Now the curious thing is that chemists do not consider the problem of the origin or the abundance of the elements to be part of their subject. You will find nothing about either of these topics in, for example, the latest edition of Chemistry by Pauling and his son (Freeman, 1975) although there are discussions of bosons, leptons, radioactivity, nuclear structure, etc.

At first sight this is a trivial objection since we need not split up subjects exactly as text-books do, but I believe that it points the way to an important distinction. In short, chemistry involves the properties of the elements and combinations of elements (traditionally at moderate temperatures and pressures), the existence of these elements being taken largely as given. This is because if an element's atomic charge and mass is given, how it originated makes no difference to its behaviour now. It could have been created yesterday or 10^9 years ago. Its chemical properties, these two numbers being given, depend only on these two numbers and of course its present environment of electrons and other atoms. Compare Newton's (or Einstein's) treatment of the motion of the solar system. The masses, positions, velocities etc. of the planets are taken as given. This is not usually an objection to saying that planetary motion can be 'reduced to physics'.

The reason I believe it important to make this distinction explicitly is because you have a confusion in your article which springs from the same source. The manufacture and putting together now of a cell from its inanimate parts is not the same problem as that of the origin of life, though the two are distantly related. One can be studied in the present. The other is necessarily historical.

Thus in discussing any subject it is important to distinguish between what features depend strongly on the past and what do not. There is also the problem of 'chance'. If this is involved in an important way in the history of the subject then it will be doubly difficult (and

in practice often impossible) to work out what actually happened.

Thus no real reductionist believes that everything can be explained. The problem then becomes what is likely to be explainable and what is not. This is the key question but it would take one far too long to attempt an answer today.

In short, as I said, I don't at all disagree with your conclusions but I don't warm to the way you have said it. Your claim that 'chemistry cannot be reduced to physics' is being widely quoted by people who have simply forgotten what your reasons were and are implying that there is some subtle flaw in what is normally meant by this claim. I myself believe that there are probably very important aspects of biology which are in principle not predictable in detail. I think the exact course of evolution is one of these things and our exact pattern of thoughts may well prove to be another. In both cases I believe, nevertheless, that very important facts and theories remain to be discovered. This will not allow detailed prediction but they will illuminate the processes, just as quantum mechanics does. But perhaps you don't agree?